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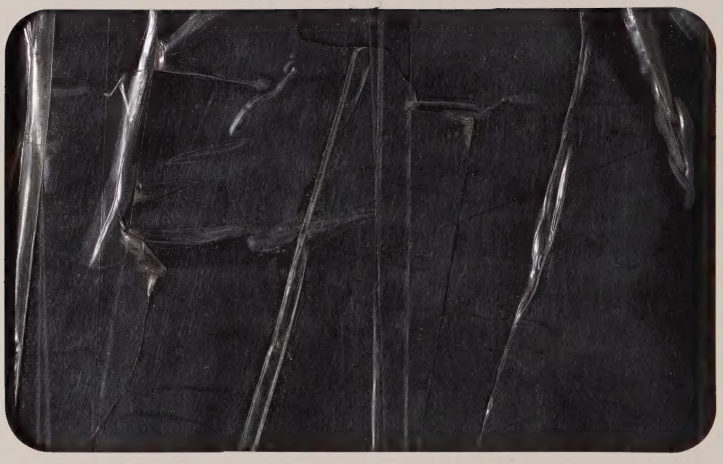
3M Photodyne Inc.

MODEL 19XT
CONTINUOUS ATTENUATOR

3M



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MODEL 19XT
CONTINUOUS ATTENUATOR

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UNITED STATES OF AMERICA

Caution

THE PERFORMANCE OF THIS INSTRUMENT IS HIGHLY DEPENDENT ON PRESERVING THE ORIGINAL QUALITY OF THE CONNECTOR INTERFACE. OBSERVE THE FOLLOWING THE PRECAUTIONS:

1) THE OPTICAL PORT(S) MUST BE KEPT COVERED AT ALL TIMES WHEN NOT IN USE.

2) ALL DUST PARTICLES AND OTHER CONTAMINANTS MUST BE EXCLUDED FROM THE OPTICAL PORT(S). WE RECOMMEND USING A LINTLESS CLOTH AND ALCOHOL TO CLEAN THE POLISHED END OF THE CONNECTOR.

3) INTERFACES TO THE INSTRUMENT MUST HAVE HIGH QUALITY TERMINATIONS WITH CONNECTORS PERFECTLY COMPATIBLE WITH THE MANUFACTURER'S TYPE AS GIVEN IN THE PHOTODYNE SPECIFICATIONS. THESE ARE HIGHLIGHTED IN THE TABLE BELOW.

NOTE: DAMAGE INCURRED AS A RESULT OF IGNORING THIS CAUTION WILL BE AT THE LIABILITY OF THE USER.

SUFFIX	MANUFACUTURER AND TYPE	SINGLE MODE	MULTIMODE
A	AMP SIMPLEX	---	501067-2
B	AMPHENOL 905/906 SMA	---	906-110-XXXX
G	DIAMOND/INTEROPTICS	HMS-3	GFS-3
H	HOLTEK 38000/STRATOS 430	---	38066
J	SEIKO FC/D3	SF-1A/SAP-1	SF-1B/SAP-2
M	DIAMOND/SIEMENS DIN 47256	D-2106	D-236
N	NEC D4	OD-9474	OD-9470
P	SEIKO/NTT FC TYPE PC	SF-1A/SAP-1	SF-1B/SAP-2
R	RADIALL OPTABALL	F714 (VFO)	F710 (PFO)
S	SIRTI BAYONET BICONIC	FC1F-/MB1	FCAF-/MBx
T	AT&T ST	P3020A-C-125	P2020A-C-125
W	AT&T BICONIC	1016A/2016A	1006A

NOTE: FOR REFERENCE PURPOSES, ALL MANUFACTURER'S PART NUMBERS ARE SHOWN FOR 125μM CLADDING DIAMETER FIBER.

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3M Photodyne Inc.
3760 Calle Tecate
Camarillo, California 93010
805/388-8378
805/499-9311 Facsimile
910 250 8611 Telex

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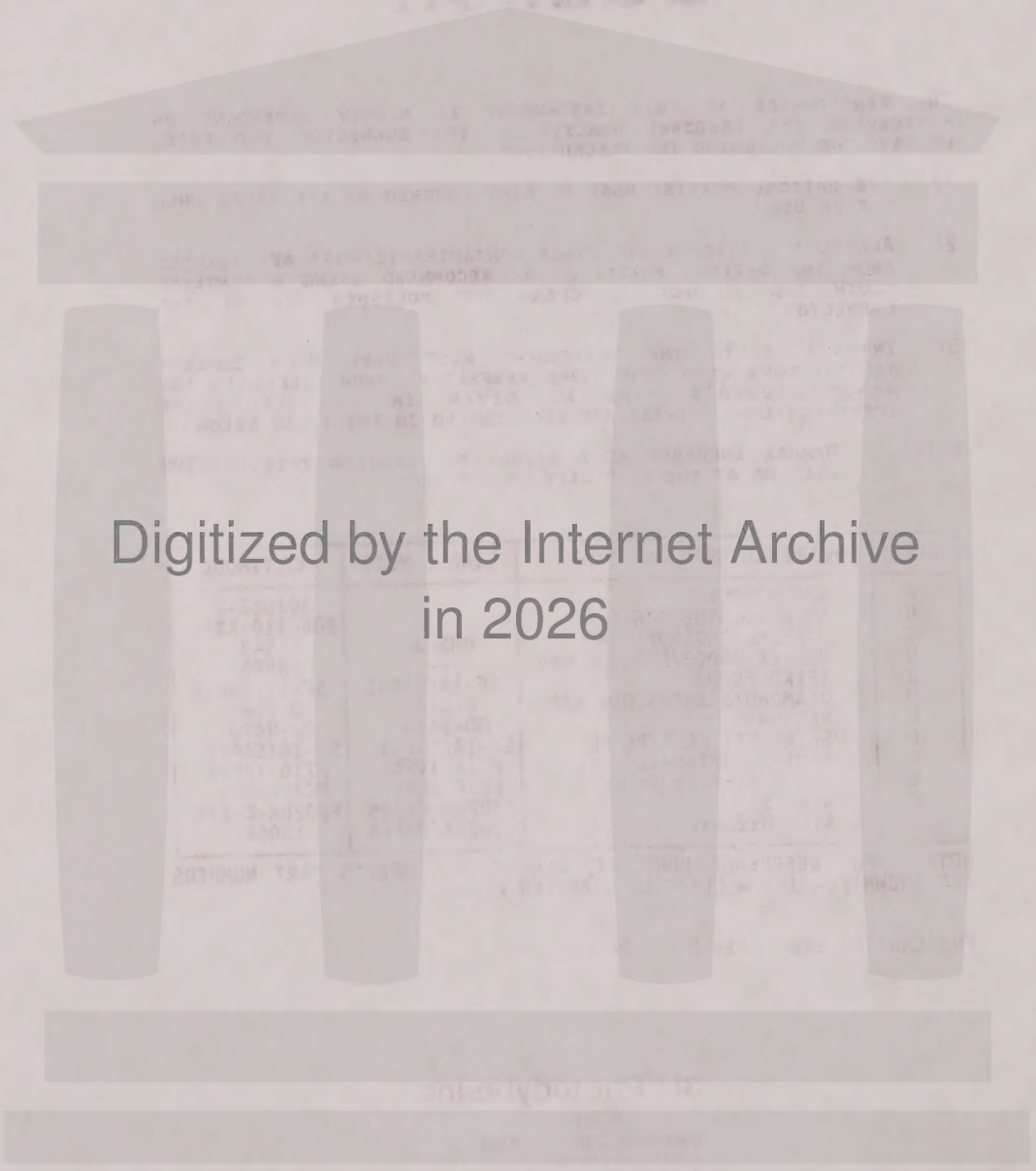

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1. GENERAL INFORMATION

1.1 INTRODUCTION

The Model 19XT Optical Attenuator is a portable and automatic instrument which provides continuous attenuation of single mode or multimode fiber optical signals in both shortwave and longwave applications. It offers a wide attenuation range and excellent resolution, combined with high accuracy. Small and lightweight, yet powerful in performance, the Model 19XT allows simple front panel operation, or external electrical signal control of attenuation. In the external mode, an analog input voltage controls the attenuation, with a scale factor of 25dB per volt input. The digital display of attenuation and wavelength is fully annunciated with all units and functions of the instrument.

The Model 19XT is available with all popular connectors options, so you can fit the instrument to your system's connector type without the need for expensive and extra loss patch cords. The internal fibers allow you to change input and output connectors when the need arises (see Section 2.10). The internal optical attenuating element is continuous. There is no discontinuous jump in attenuation as in instruments which employ step filters or combination step/continuous filters. Thus your sensor/receiver does not experience baseline shifting jolts of charge.

The Model 19XT multimode versions are calibrated at 850nm and 1300nm. The Model 19XT single mode versions are calibrated at 1300nm and 1550nm. A freely adjustable display offset of dB attenuation is a feature that allows you to include insertion loss in the displayed attenuation values at all calibration wavelengths.

Applications

* System Testing
* Power Meter Calibrations
* F/O Environmental Component Testing
* Bit Error Rate Testing
* Field and Lab Application

Features

* Small Size and Lightweight
* Front Panel and External Automatic Control
* Low Insertion Loss
* Multimode or Single Mode
* All Connector Options
* 0 - 70dB Attenuation (850nm and 1300nm)
* 0 - 60dB Attenuation (1550 nm)
* 0.1dB Resolution
* Front Panel Auto Scan and Repeat Scan
* Dark State

1.2 SPECIFICATIONS

MULTIMODE MODELS

Optical Specifications

Cal Wavelengths:	850nm and 1300nm		
Attenuation Range:	70dB ±2dB at 850nm 70dB ±2dB at 1300nm		
Accuracy (Note 1):	±0.2dB, typical Greater of ±0.5dB or ±2%, maximum		
Internal Insertion Loss (Note 2):	2.5dB, typical 3.5dB, maximum		
Back Reflection (Note 3):	Less Than -20dB		
Internal Fibers (typical)			
Core/Clad diameter:	50/125µm	62.5/125µm	100/140µm
Numerical Aperture:	0.21	0.29	0.28
Type:	All Graded Index		

SINGLE MODE MODELS

Optical Specifications

Cal Wavelengths:	1300nm and 1550nm
Attenuation Range:	70dB ±2dB at 1300nm 60dB ±2dB at 1500nm
Accuracy (Note 1):	±0.2dB, typical Greater of ±0.5dB or ±2%,maximum
Internal Insertion Loss (Note 2):	3.5dB, typical 5dB, maximum
Back Reflection (Note 3):	Less Than -20dB
Internal Fibers (typical)	
Core/Clad diameter:	9/125µm
Numerical Aperture:	0.10
Material:	silica/silica
Type:	Step Index

Operational Specifications

Optical Resolution:	0.1dB
Scan Speed:	0 - 70dB in 35 seconds (Front Panel) 0 - 70dB in 15 seconds (Ext Control)
Display:	Direct LCD read-out of attenuation and cal wavelength.
Analog Out:	+1 volt out per -10dB of attenuation, 0-8 volts, maximum load 10kΩ. Accuracy : ±0.1dB with respect to display reading.
Analog In:	-25dB per volt in, 10kΩ load.
Battery Type:	Includes two built-in Ni-Cd rechargeable cells. Capacity: 8.4V/225mA-hr. Reorder as Photodyne Model BH96 (2 required).
Battery Life:	12 hours, typical (non-REPEAT SCAN mode)
AC Operation:	100 VAC with Model 100B 115 VAC with Model 115B 220 VAC with Model 220B

Environmental Specifications

Operating Temperature:	0 to 40°C
Storage Temperature:	-10°C to +60°C
Relative Humidity:	0 - 90%, Non-condensing

Physical Specifications

Weight:	1.5 kg (3.3 lbs.)
Height:	183mm (7.3 in.)
Width:	102mm (4.0 in.)
Depth:	74mm (2.9 in.)

All optical and operational specifications are measured at an ambient temperature between 18°C and 25°C.

SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE

Note: (1) In any precision optical filter, slight imperfections are inevitable with the tight tolerances required for the most experienced optical manufacturers. These are noted as narrow peaks or valleys on the linearity curves provided as part of the calibration report. Photodyne's accuracy specifications require that not more that two minor imperfections (not to exceed 1.0 dB) are allowed.

(2) Total Insertion loss is defined as the sum of the Internal Insertion Loss of the 19XT plus the connector loss from the two connectors on the front panel. The test methods for these parameters are described in Section 6- Performance Verification. The connector loss is determined by the particular connector type you choose, and the individual connector you hook up with. A connector loss maximum cannot be guaranteed, but our experience shows a typical range from 1dB to 3dB per connector. All insertion loss measurements are made with core light only (cladding light stripped), and a close approximation to an equilibrium mode distribution.

(3) Back Reflection is defined as the back reflection off the internal optics of the 19XT, and **does** not include connector effects (which are determined by the connector design). The use of low-reflectance connectors, such as the Seiko/NTT FC Type PC single mode connector ("P" Option), will ensure system performance to about -20dB. High reflectance connectors, such as the SMA, exhibit poorer back reflection characteristics which degrade the total back reflection performance to about -15dB. Consequently, users concerned with back reflectance should use and specify low reflectance connectors.

1.3 ORDERING INFORMATION

The Model 19XT must be ordered with additional letter and number designations. The following options are available:

Model Number	Fiber Type	Connector Type
19XT-010G	9/125µm, SM	Interoptics/Diamond HMS-3
19XT-010J	9/125µm, SM	Seiko/NTT FC/D3
19XT-010M	9/125µm, SM	Diamond/Siemens DIN 47256
19XT-010N	9/125µm, SM	NEC OD-9474/D4
19XT-010P	9/125µm, SM	Seiko/NTT PC
19XT-010R	9/125µm, SM	Radiall VFO 714
19XT-010S	9/125µm, SM	SIRTI Bayonet-Type Biconic
19XT-010T	9/125µm, SM	AT&T ST
19XT-010W	9/125µm, SM	AT&T 1016A Biconic

Model Number	Fiber Type	Connector Type
19XT-050B	50/125µm, MM	Amphenol 906 SMA
19XT-050G	50/125µm, MM	Interoptics/Diamond GFS-3
19XT-050H	50/125µm, MM	Holtek 38000/Stratos 430
19XT-050J	50/125µm, MM	Seiko-NTT Type FCN/D3
19XT-050M	50/125µm, MM	Diamond/Siemens DIN 47256
19XT-050N	50/125µm, MM	NEC OD-9470/D4
19XT-050R	50/125µm, MM	Radial PFO 710
19XT-050S	50/125µm, MM	SIRTI Bayonet-Type Biconic
19XT-050W	50/125µm, MM	AT&T 1006A Biconic
19XT-062T	62.5/125µm, MM	AT&T ST
19XT-100B	100/140µm, MM	Amphenol 906 SMA

1.4 THE PHOTODYNE XT FAMILY OF PORTABLE INSTRUMENTS

The XT style case of Model 19XT attenuator is polyurethane foam molded over a metal frame. This super rugged protective case allows both lab and field operation. Three other instruments in the XT product line comprise a complete family of portable test instruments:

* Model 21XTL Test Set/Talk Set

* Models 17XTA/17XTF/18XTA Fiber Optic Power Meters

* Model 9XT Modular Fiber Optic Source Driver utilizing 1700 series LED and Laser Source Modules

1.5 WARRANTY INFORMATION

PHOTODYNE, INC. warrants this product to be free from defects in material and workmanship for a period of one year from date of shipment. During the warranty period, we will, at our option, either repair or replace any product that proves to be defective.

To exercise this warranty, write or call your local PHOTODYNE Representative, or contact PHOTODYNE Headquarters. You will be given prompt assistance and return instructions. Send the instrument, transportation prepaid, to the indicated service facility. Repairs will be made and the instrument returned, transportation prepaid. Repaired products are warranted for the balance of the original warranty period, or at least 90 days.

LIMITATION OF WARRANTY

This warranty does not apply to defects resulting from unauthorized modification or misuse of any product or part. This warranty also does not apply to fuses, batteries, or damage from battery leakage.

This warranty is in lieu of all other warranties, expressed or implied, including any implied warranty of merchantability of fitness for a particular use.

PHOTODYNE, INC. shall not be liable for any indirect, special or consequential damages.

1.6 STATEMENT OF CALIBRATION

This instrument has been inspected and tested in accordance with specifications published by PHOTODYNE, INC. The accuracy and calibration of this instrument is traceable to the National Bureau of Standards through equipment which is calibrated at planned intervals by comparison to certified standards.

It is recommended that this instrument be recalibrated every year. This provides the basis for an effective quality assurance/standards program. This service is available for PHOTODYNE products for nominal fee.

1.7 CHANGE NOTICE

Improvements or changes to the instrument not incorporated into the manual will be explained on a yellow change notice sheet attached to the inside back cover of the manual.

2. INITIAL PREPARATION

2.1 General

This section provides information needed for incoming inspection and preparation for use.

2.2 Inspection

The Automatic Attenuator was carefully inspected both mechanically and optically before shipment. When received, shipping carton should contain the Optical Attenuator as ordered. Account for and inspect each item before the carton is discarded. In the event of a damaged instrument, write or call your local PHOTODYNE representative, or contact PHOTODYNE Headquarters. Please retain and use the shipping carton if reshipment is required.

2.3 Damaged In Shipment

All instruments are insured when shipped by PHOTODYNE. If you receive a damaged instrument you should:

1) Report the damage to your shipper immediately.
2) Inform your local PHOTODYNE representative or PHOTODYNE directly.
3) Save all shipping cartons.

Failure to follow this procedure may affect your claim for compensation.

2.4 Contents

(1) Model 19XT Fiber Optic Attenuator

(1) Briefcase-style Carrying Case

(1) Model 19XT Instruction Manual

(1) Certificate of Calibration and Metrology Report package

(1) Battery Charger (specific model as ordered)

Model 100B : 90 - 110VAC, 50Hz
Model 115B : 104 - 126 VAC, 60Hz
Model 220B : 198 - 242 VAC, 50/60Hz

(1) Warranty Registration Card (return immediately after check-out).

Figure 2.1 Contents of Model 19XT

2.5 Preparation For Use

The Model 19XT is shipped ready-to-use. The instrument is powered from the internal rechargeable battery pack or the external AC power supply/charger (100B, 115B or 220B).

2.6 Battery Installation/Replacement

The rechargeable batteries furnished with the Model 19XT Fiber Optic Attenuator comes already installed inside the unit. These batteries are 8.4V/225mAh rechargeable NiCd cells and may be ordered as PHOTODYNE Model BH96 (2 required). To replace the battery, first remove the 19XT top cover, then remove old batteries and install new ones, and finally, re-attach the top cover. This procedure is described in detail in the following paragraphs.

****
* WARNING *
****

TO AVOID ELECTRICAL SHOCK AND/OR INSTRUMENT DAMAGE, TURN OFF THE INSTRUMENT AND REMOVE ALL CONNECTIONS BEFORE REPLACING THE BATTERY.

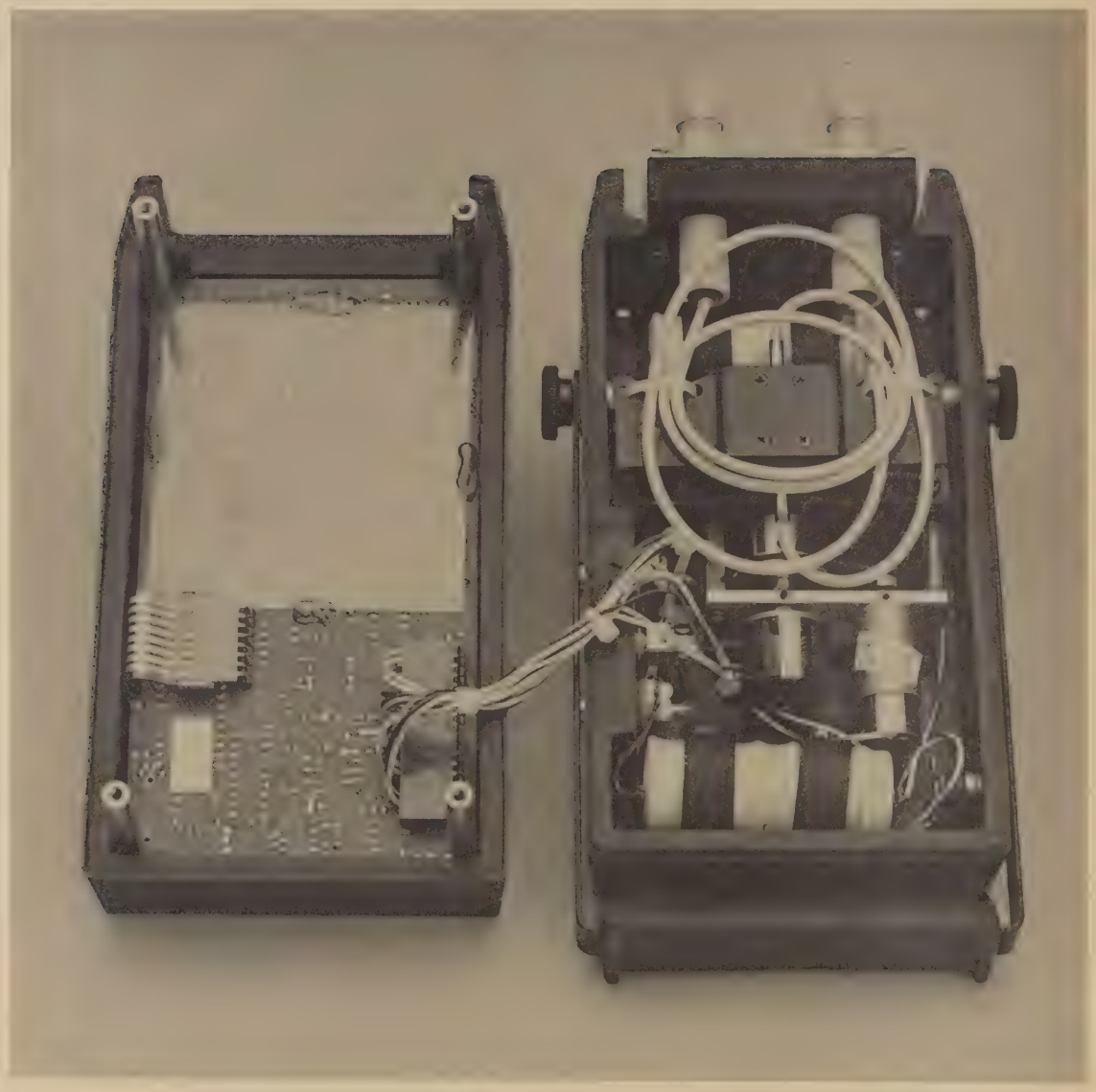


Figure 2.2 Assembly/Disassembly of Model 19XT

Removing Top Cover

Hold the instrument in hand so that the bottom cover faces up. Loosen the screws at the four corners. Turn the instrument over with the top cover facing up, taking care to hold the top and bottom covers together. Carefully lift the top cover and lay aside the bottom cover to expose the printed circuit board, as shown in Figure 2.2.

Battery Removal/Replacement

Be sure the instrument is off. Remove batteries by removing the nuts holding down the battery straps. Desolder the battery lead connections. Resolder these lead connections to the new batteries, being careful of polarity. Reinsert the new batteries in the battery clips and tighten down the nuts on the battery clips.

Replace the Top Cover

Lay the top cover next to the bottom cover with the printed circuit board exposed (as shown in Figure 2.2). Carefully lift the top cover and place it on the Bottom Cover. Make sure that the electrical cables do not press on the optical cables, and that the optical cables are not overlapping where they are tied down to the filter assembly. Also make sure that there are not excessive bends in the optical cables. Failure to do so will result in higher insertion losses, and possible optical cable damage. Turn the

instrument over with the bottom cover facing up and re-install the four cover screws.

2.7 How To Check The Battery

Whenever the Model 19XT is on, the battery condition is continuously monitored. A low battery condition exists when the battery voltage falls below about 7 volts. This is indicated by a "LO BAT" appearing in the upper left hand corner of the LCD display. If the "LO BAT" appears or the instrument does not operate at all, first suspect a discharged battery and charge according to the procedure given in the following section.

****
* NOTE *
****

If the battery voltage falls below about 4 volts, the shutoff circuitry will not work properly and the user may not be able to turn the unit off. The battery charger must then be connected to the 19XT in order to turn the unit off. In addition, if the battery is allowed to completely discharge, the battery may be damaged. Thus if the unit is going to be used for extended periods with the Auto Shutoff feature disabled, it is recommended that the battery charger be connected to the 19XT. The Auto Shutoff feature is described in section 3.1.

2.8 How To Charge The Battery

The Model 19XT provides built-in recharging circuitry for recharging the Model BH96 battery pack. To recharge the internal battery, connect the appropriate PHOTODYNE battery charger to the "CHARGER" connector on the side panel of the Model 19XT with POWER OFF as shown in Figure 2.3. Refer to Table 2.1 for correct battery charger selection, according to available AC electrical power. A full charge will typically require approximately 14-18 hours. The Model 19XT may be operated while the power supply charger is plugged into the unit. The circuitry is designed so that the battery will not overcharge by providing a constant trickle charge as defined by manufacturer's specifications.

****
* NOTE *
****

NO OTHER AC POWER SUPPLY/CHARGER OTHER THAN A PHOTODYNE MODEL 100B, 115B, OR 220B MAY BE CONNECTED TO THE CHARGER INPUT, AND NO OTHER BATTERY THAN THE PHOTODYNE MODEL BH96 MAY BE USED. IMPROPER USE VOIDS THE PHOTODYNE WARRANTY.

TABLE 2.1

BATTERY CHARGER SELECTION CHART

MODEL	AVAILABLE AC POWER	COUNTRY
100B	89 - 110 VAC, 50 Hz	JAPAN
115B	105 - 129 VAC, 60 Hz	USA, CANADA
220B	207 - 253 VAC, 50/60 Hz	EUROPE

Figure 2.3 Battery Charger Connection to the Model 19XT

2.10 How To Change The Connectors

The Model 19XT uses internal optical fibers to carry the optical signals into and out of the variable attenuation filter. These input/output fibers are terminated at the front panel in connectors while the feedthrough couplers are mounted in a removable plate. There is enough useful length of fiber cable within the instrument to allow cutting off the old connectors and reterminating the fiber with a new connector type. If the user wishes to convert his unit to another connector type, a blank adaptor plate is available, and may be ordered as Photodyne stock number, 78C-0019-13.

To obtain access to the internal fibers and to change the mounting plate, follow the disassembly instructions already given in Section 2.7 - Battery Installation/Replacement.

3. OPERATING INSTRUCTIONS

3.1 GENERAL

This section provides information needed to operate the 19XT Optical Attenuator. This includes the operation of all controls and input/outputs.

3.2 PRINCIPLES OF OPERATION

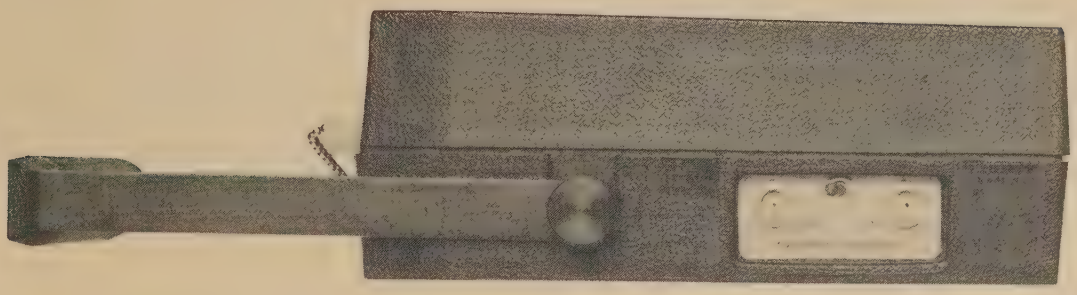
The Model 19XT attenuates optical power between the two optical ports on the front panel. Behind the front panel connector interfaces, optical fibers carry the light signals to an expanded beam optical system, which expands the light from the input fiber into a collimated beam, and then refocuses it into the exit fiber. A continuously variable neutral density filter is located between the two lenses. The position of this neutral density filter, with respect to the lenses is controlled by the front panel switches or external voltage. These switches control the attenuation of the Model 19XT by changing the position of the variable filter with respect to the collimated beam, through an internal servo motor system.

3.3 OPERATING CONTROLS

3.3.1 ELECTRICAL POWER (ON/OFF)

If the 19XT is OFF, press **[ON/OFF]** button to turn the unit ON. If the 19XT is ON, press and release the **[ON/OFF]** button to turn the unit OFF. When the unit is turned on, it will have the Auto Shutoff feature enabled. This means that if no keys are pressed in a ten minute period, the 19XT will turn itself OFF. To disable the Auto Shutoff feature, press and hold down the **[ON/OFF]** button until the **AUTO PWROFF** indicator goes off (about 5 seconds), then release the **[ON/OFF]** button. To re-enable the Auto Shutoff feature, press and hold down the **[ON/OFF]** button until the **AUTO PWROFF** indicator comes back on, then release the **[ON/OFF]** button.

3.3.2 SELECTABLE FRONT PANEL OR EXTERNAL CONTROL



With the inset switch to the left (OFF), as above, the front panel buttons control attenuator operation. With the switch to the right (ON), an external input voltage will control attenuation operation; -25dB per +1 Volt of input to the BNC labeled **EXTERNAL CONTROL IN.** The BNC labeled **dB SIGNAL OUT** always provides a voltage output proportional to the displayed attenuation value, -10dB per +1 volt of output.

****
* NOTE *
****

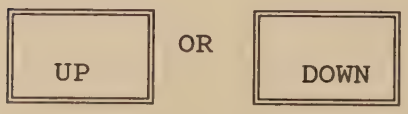
The front panel keys - **[UP]**, **[DOWN]**, and **[SCAN]** - will have no effect when the **EXTERNAL CONTROL SWITCH** is set to the ON position.

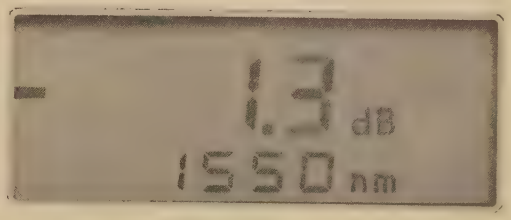
When initially switched to External Control ON position, the Auto Shutoff feature is disabled. However, the Auto Shutoff feature can be re-enabled by pressing and holding the **[ON/OFF]** button until the **AUTO PWR OFF** indicator reappears, then releasing the [ON/OFF] button.

3.3.3 WAVELENGTH SELECT

Press the [λ] button until the wavelength display corresponds to that wavelength being brought into the 19XT. Normally the dB reading on the 19XT will not change when a new wavelength is selected, but if the dB reading is greater then the maximum allowed for the new wavelength, the reading and attenuation will be changed to this maximum, and the **MAX** indicator will come on.

3.3.4 UP/DOWN ATTENUATION CONTROL





Press the **[UP]** button to increase dB attenuation value. Press the **[DOWN]** button to decrease dB attenuation value. Hold on the **[UP]** or **[DOWN]** button for several seconds and the rate of change of dB value will increase to a maximum rate.

3.3.5 SCAN Control

Press and release **[SCAN]** button and the 19XT will automatically move (scan) from its current dB value to a preset dB value, called MEM #1. Press and release the **[SCAN]** button again and the 19XT will scan to a second preset dB value called MEM #2. Each time **[SCAN]** is momentarily depressed, the 19XT will alternately switch between MEM #1 and MEM #2 attenuation values.

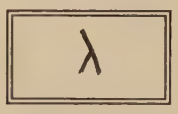
If MEM #1 or MEM #2 is set to a value greater then the 19XT can reach, the unit will move to the maximum attenuation value for the current wavelength and turn on the **MAX** indicator. If MEM #1 or MEM #2 is set to a value lower then the 19XT can reach, the unit will move to its lowest value and turn on the **MIN** indicator. This can only happen if X+B is enabled.

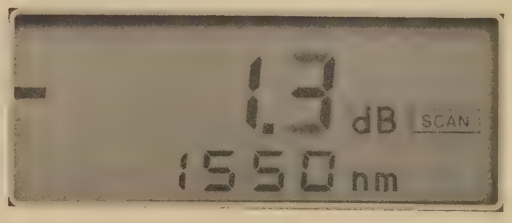
For example, if X+B is on and B is set to -5.0dB, the lowest attenuation the 19XT can go to is -5.0dB. It can not go to -0.0dB. So if MEM #1 is set to -0.0dB and the **[SCAN]** button is pressed, the 19XT will move from its

current attenuation to -5.0dB and the **MIN** indicator will be on, but the **MEM #1** indicator will not be turned on since the unit could not reach MEM #1.

In order to change the dB values stored in MEM #1 and MEM #2, the following procedure is required: Hold down the **[SCAN]** button for five seconds, until the MEM #1 display indicator blinks. Use the **[UP]** and **[DOWN]** buttons to go to the desired dB value for the new MEM #1 value. Press and release the **[SCAN]** button to store MEM #1. The MEM #2 display indicator will now blink. Use the **[UP]** and **[DOWN]** buttons to go to the desired dB values for the new MEM #2 position. Press and release the **[SCAN]** button once again and the new MEM #2 value will be stored. These values will remain in computer memory even when the power is off.

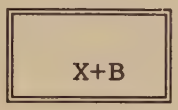
3.3.6 REPEAT SCAN





Press and hold down the [λ] button for five seconds, until the **SCAN** indicator comes on. Release the [λ] button and the 19XT will repeatedly do the Scan function as described above. Pressing any key will stop the Repeat Scan.

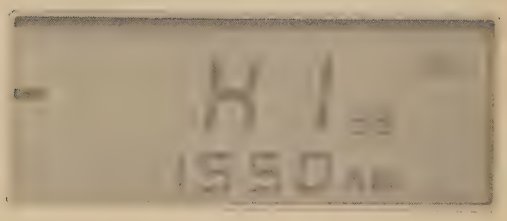
3.3.7 X+B CONTROL



Momentarily depress [X+B] in order to add a constant dB value (B) to the display of attenuation. For instance, if the B value has been preset to -5dB, then when the [X+B] button is pressed, -5dB will be added to all display values of attenuation. Whenever this B value is included in the displayed attenuation, **X+B** will appear in the display. Momentarily press **[X+B]** again to disable the X+B function and remove the B offset value from the readout.

This X+B function can be used to include the 19XT insertion loss in the displayed dB value. It can also be used to bring the displayed dB value to the absolute dBm value of a power meter connected to the 19XT optical output. In order to change the stored B value, the following procedure is required: Hold down [X+B] for five seconds until the **X+B** indicator begins to blink. Use the [UP] and [DOWN] buttons to select the desired value for B. Press and release [X+B] once again. The new B value will be stored and will be added to the displayed attenuation whenever the [X+B] function is enabled. The B value is preserved in E^2PROM memory even when the power is off.

3.3.8 DARK STATE

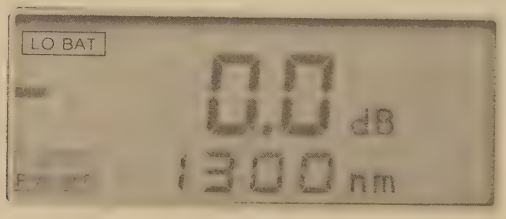


The Dark State can be achieved with the 19XT by holding down the [UP] button for five seconds after the instrument has been taken to the **MAX** dB position. Hold down the [UP] button until **MAX** appears in the display. Hold down the [UP] button for five seconds longer and **-HI** will appear in the dB display space. The 19XT is now blocking all light between input and output optical ports.

3.4 Operating Notes

3.4.1 Display Annunciators

When **LO BAT** appears in the display, the instrument needs to be recharged.



When **AUTO PWR OFF** appears in the display, the 19XT will automatically turn off ten minutes after the last button is pressed.

When **MIN** appears in the display, no further reduction in attenuation can be obtained. If the X+B function is activated, the displayed value of attenuation will be the preset **B** value.

When **MAX** appears in the display, no further increase in attenuation can be obtained. If the **X+B** function is activated, the displayed value of attenuation will be the maximum limit plus the **B** value.

3.4.2 Absolute Attenuation and Insertion Loss

The digital display of the Model 19XT begins at zero and has a resolution of 0.1dB, up to the maximum attenuation value. Zero dB on the display (X+B function off) is the minimum attenuation setting of the instrument. This does not mean, however, that the instrument has no attenuation at the zero dB setting. The absolute attenuation of the instrument at the zero dB position is called the insertion loss.

The insertion loss of the Model 19XT is comprised of two parts: the internal optical insertion loss, and the connector loss from the two connectors on the front panel. The experimental methods for determining these factors are discussed in Section 6 - Performance Verification. The connector loss is determined by the particular connector type you choose, and the individual connector you hook up

with. A connector loss maximum cannot be guaranteed, but our experience shows a typical range from 1dB to 3dB per connector. In order to eliminate connector losses, one can fusion splice into the Model 19XT. This is done by pulling out a length of the internal fiber, and cutting off the connector. We recommend the Seiko FC or AT&T Biconic versions for this application. All insertion loss measurements are made with core light only (cladding light stripped), and a close approximation to an equilibrium mode distribution.

This insertion loss is effectively added to every position of the readout. For example, assume a total insertion loss of 5dB. Then, when the Model 19XT reads 0dB, the absolute loss is actually 5dB; when the instrument readout is 10dB, the absolute loss is 15dB; when the instrument readout is 35dB, the absolute loss is 40dB, etc. The insertion loss factor for your particular setup can be added to the displayed attenuation value by using the X+B function, described in Section 3.3.7.

3.4.3 Parameter Storage

When the display is blank, the instrument is off. When off, the dB attenuation value will not change. Also, the values for B, MEM #1, MEM #2, the last displayed dB attenuation, λ, and the X+B state (ON/OFF), will be stored

in E^2PROM memory. These values will be reinstituted in active computer memory when the instrument is turned back on.

3.5 Precautions

The user is cautioned to be aware that optical measurements are probably among the most difficult of the physical sciences to quantify with precision and repeatability. Fiber optics, because of their small diameters, pushes this science to its near limits. The difficulties that can be encountered generally fall into two broad categories; measurment errors and test conditions.

3.5.1 Measurement Errors

These relate to the problem of achieving repeatable readings even by one technician using a single set of test equipment. Often the values being measured can be totally obscured by the quality of the coupling (connector), the concentricity of the fiber and the quality of the input and exit fiber surfaces.

3.5.2 Test Conditions

Even with the best equipment, a careless or inexperienced user can obtain erroneous or totally meaningless results because of mechanical misalignment, fluctuating test

conditions or various obscure mechanisms within the fiber itself. For measurements to be valid, test conditions must be stable, repeatable and controlled.

3.6 Fiber Connections to the Attenuator

Your Model 19XT is supplied with connectorized internal fibers, terminated in female/female bulkhead joints in the front panel mounting plates. You must hookup to the Model 19XT with fibers terminated in connectors matching those supplied with the instrument. Remember, both the fiber type and connector type must match the internal fiber type and the exact connector type.

For hooking up to unconnectorized fiber pigtails, we recommend the 2038 series of bare fiber adopters, described in the PHOTODYNE catalog.

3.6.1 Optical Ports

There are two optical ports on the Model 19XT, labeled **INPUT** and **OUTPUT**. Be sure your light signal comes into the **INPUT** port and goes out the **OUTPUT** port. Calibration factors may not be accurate otherwise.

3.6.2 Optical Fiber Precaution

During the measurement cycle it is most important that the input and output fibers, at the attenuator, remain

straight and undisturbed. Flexing and/or bending these fibers during measurement can degrade the measurement accuracy by as much as several dB.

3.6.3 Minimizing Connector Losses

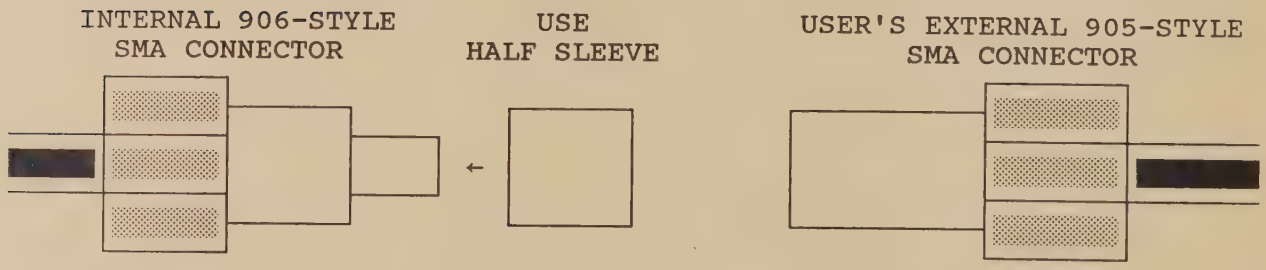
You can minimize connector loss factor in three ways: (1) Choose a connector type to begin with that is specified as low loss by the manufacturer; (2) If the connector is rotatable (as are SIMPLEX and SMA types), rotate the connector, after insertion, for maximum signal throughput; and (3) Use an index matching gel on the ends of the connectors, in order to avoid reflection losses.

3.6.4 SMA Connector Precautions

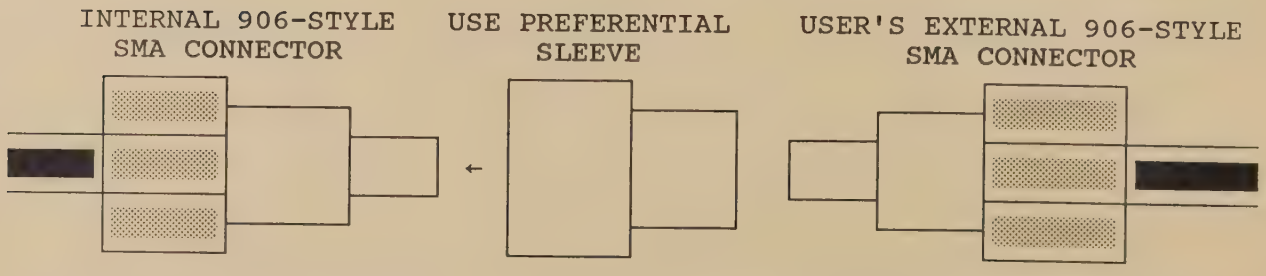
The Model 19XT-050B and 19XT-100B incorporate an internal fiber which is factory-terminated with an Amphenol 906 series SMA connector and is fitted with a PREFERENTIAL full length alignment sleeve. The PREFERENTIAL sleeve allows direct coupling of external 906-style connectors. If the user has 905-style connectors, he must remove the PREFERENTIAL sleeve mounted on the internal 906-style connector and replace this with the HALF length sleeve.

When necessary to change the internal sleeve, the user gains access to the internal connectors by removing the top cover as described in section 2.7. The internal

connectors are then exposed on the inside of the front panel connector plate/bulkhead coupler combination. For this example, assume the external connector is a 905 type. Unscrew these connectors, remove the PREFERENTIAL full length sleeve (internally mounted at the factory), and replace it with a HALF length sleeve. Re-connect the connectors to the bulkhead coupler. Re-assemble the 19XT as described in the same section. High insertion loss (up to 5dB) is not unusual for a 905 or 906 SMA connector.



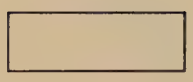
(A) Use HALF sleeve for interfacing to external 905 SMA



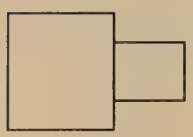
(B) Use PREFERENTIAL sleeve for interfacing to external 906 SMA

Figure 3.1 Selecting Proper Sleeve for 905/906 SMA Connectors

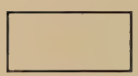
Users of Amphenol 906 series SMA connectors should be aware that Amphenol manufactures and supplies special alignment sleeves (packaged with every 906 series connector) which are required when mating two SMA connectors. Their usage is necessary in order to obtain performance consistent with the manufacturer's specifications. The following diagrams will help the user identify the three different types of alignment sleeves (and their proper usage):



STANDARD, full length alignment sleeve (green, Amphenol P/N 906-101-3001) is used for any 906 to 906 interface. This is now an obsolete Amphenol product, replaced by the PREFERENTIAL sleeve.



PREFERENTIAL, full length alignment sleeve (red Amphenol P/N 906-101-3003) is now used for any 906 to 906 interface, however, its design enables the larger diameter end to remain captivated onto specified 906 connector.



HALF length alignment sleeve, (white, Amphenol P/N 906-101-3002) is installed on the 906 connector in all 906 to 905 interfaces to insure precision alignment.

3.7 Typical Measurement Setup

Figure 3.2 shows a typical measurement setup. The Model 19XT is located in the optical power path between the signal generator and the receiver. By varying the atte nuator setting, the optical power into the photo receiver is varied in a calibrated fashion. One can check the power linearity of receivers in this type of setup. One can also

measure the minimum detectable power level in analog systems, or the B.E.R. in digital systems.

Example: This setup can measure the linearity and minimum detectable optical power level of the receiver under test. The receiver is a PHOTODYNE Model 17XTA Fiber Optic Power Meter, and the source is a Model 9XT with 1710SM1300W Plug-in Laser Source Module.

Figure 3.2 Typical Measurement Setup Using The 19XT.

3.8 Error Codes

Error codes should not occur during normal operation. If an error code does occur, pressing any keyboard button will resume 19XT operation.

ERROR CODE	CONDITION
E 1	Display overflow. Tried to display a number less than -199.9
E 2	Calibration Error.
E 3	Illegal CPU opcode. CPU error.
E 4	RAM error.
E 5	Checksum error. EEPROM checksum incorrect. Stored Parameters lost.
E 6	EEPROM error. EEPROM could not be written to.

4. SYSTEM SIMULATION

4.1 General

To use the attenuator for systems simulation or modeling, it is first necessary to formulate an optical loss budget. A sample worksheet is given on the following page. A detailed knowledge of the performance parameters of the various components in the fiber optics link is essential. It is helpful to present this information in graphical form as shown in Figure 4.1. The formulation is best worked out in dBm units as this allows easy addition or subtraction of the various calculations.

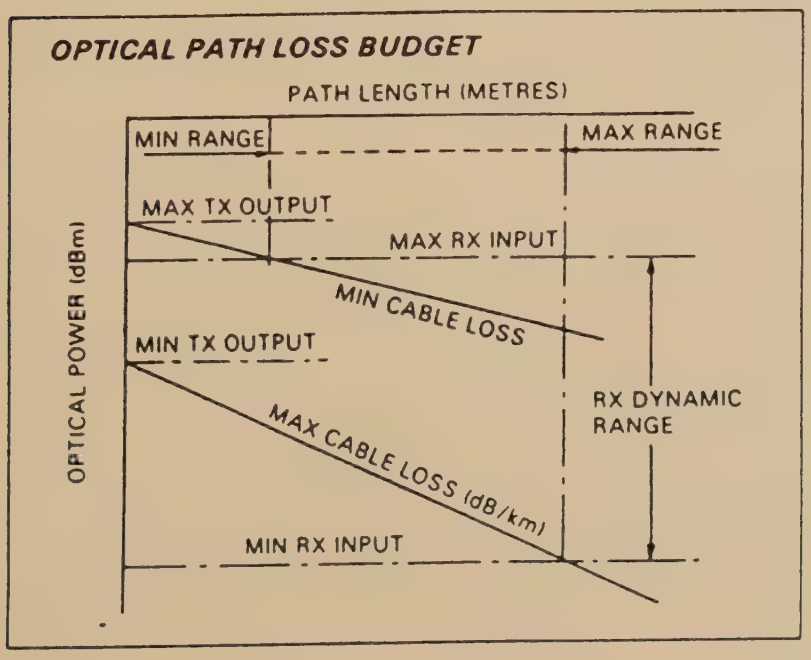


Figure 4.1 Optical Path Loss Budget

LINK LOSS BUDGET

LINK DESCRIPTION

Data Rate (R) _____ (Mb/s)
Length (L) _____ (km)
Operation Wavelength (λ) _____ (nanometers)

TRANSMITTED POWER (P_T)

Light Source Type _____
Average Source Power _____ (mW)
_____ (dBm)
Fiber Coupling Loss _____ (dB)
Average Transmitter Power _____ (dBm)

REQUIRED RECEIVER POWER (P_{REQ})

Detector Type _____
Required BER _____
Receiver Bandwidth _____ (MHz)
Receiver Sensitivity _____ (dB)
Required Receiver Power _____ (dBm)

ALLOWED LINK LOSS

$P_T - P_{REQ} =$ _____ - _____ = _____

LINK LOSS

CONTRIBUTOR	UNIT		NUMBER		TOTAL	
Connectors	_____	(dB)	_____		_____	(dB)
Splices	_____	(dB)	_____		_____	(dB)
Cable	_____	(dB/km)	_____	(km)	_____	(dB)
Mixer/Splitter	_____	(dB)	_____		_____	(dB)
Cable Repair Margin	_____	(dB)			_____	(dB)

TOTAL LINK LOSS ..... _____ dB

4.2 Transmitter

Two values of output (in dBm) must be specified:

Maximum Output
* Highest specification limit
* Start of life
* Maximum under operating conditions (temperature, supply voltage, etc.)

Minimum Output
* Lowest specification limit
* End of life
* Minimum for operating conditions

4.3 Receiver

Two values of input (in dBm) must be known:

Maximum Input
* Overload condition

Minimum Input
* Minimum required for the maximum bit error rate (BER) in a digital receiver, or minimum signal-to-noise ratio (SNR) in an analog receiver

4.4 Cable and Connectors

Maximum and minimum attenuation of the cable in dB/km at the transmitter wavelength must be known for the actual environmental conditions. In addition, fiber core diameter and numerical aperture (NA) are required. Minimum and maximum values for connector insertion loss -- again, under operating environmental conditions -- must be specified. The dB values are summed.

4.5 Sample Loss Budget

The loss budget is now plotted in the form shown in Figure

4-2. The values are summed.

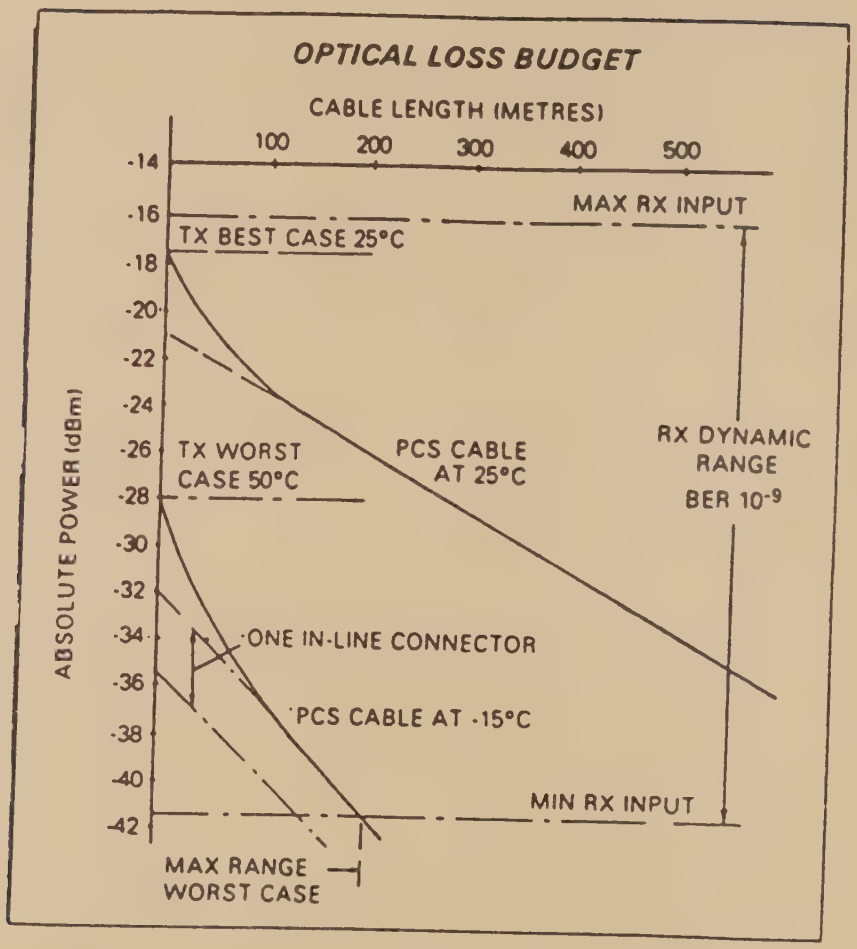


Figure 4.2 Sample Loss Budget

4.6 Using the Attenuator

Systems performance may now be simulated in the laboratory on a representative length of fiber cable.

(a) Connect the transmitter to the optical port of the attenuator

(b) Connect the fiber cable/receiver link to the OUTPUT optical port of the attenuator.

(c) On the attenuator, dial in the value of attenuation.

NOTE

Attenuation settings are without insertion loss, which should be accounted for as described in Section 3.4.2.

4.7 Component Evaluation

To avoid overspecifying or underspecifying components in the engineering stage, Photodyne attenuators may also be used to help determine:

* Receiver threshold levels
* Transmitter optical power level

To perform the above measurements, use the same setup as described in Section 4.6.

5. AUTOMATIC OPERATION OF THE MODEL 19XT

5.1 General

The Model 19XT is capable of being controlled with external input analog voltage signals. In addition, an output analog voltage is always available, which tracks the display value of attenuation. This section describes the use of these features.

5.2 dB SIGNAL OUT (Analog Output)

Under either condition of operation, front panel or external control, an analog voltage exists at the BNC terminal on the instrument left side labeled **dB SIGNAL OUT**. The conversion factor is +1 volt of output per 10dB of attenuation.

Figure 5.1 shows a block diagram of an automatic control system utilizing the **dB SIGNAL OUT** and **UP/DOWN** or **SCAN** functions of the 19XT. This setup will automatically plot receiver linearity and noise level. In this photograph, a Model 9XT/1710SM1300W 1300nm laser source is inputting light to a single mode fiber cable. This cable goes to the input of the Model 19XT attenuator. The single mode cable out of this Model 19XT attenuator goes to a 22XLC/550 Power Meter/Sensor combination. The X axis of the pen plotter is driven by the 22XLC **ANALOG OUTPUT**, and the Y axis is driven by the **dB SIGNAL OUT** analog output of the Model 19XT.

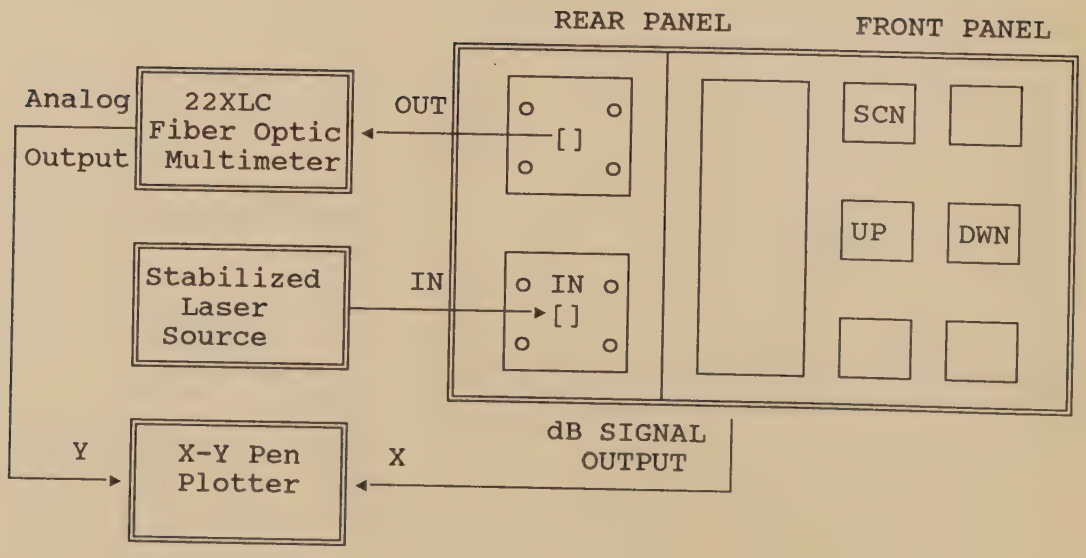


FIGURE 5.1 BLOCK DIAGRAM OF AUTOMATIC TEST SETUP USING 19XT dB SIGNAL OUTPUT ONLY

The user can drive the 19XT by holding down the front panel **[UP]** or **[DOWN]** keys of the Model 19XT. Alternately, the user could program the MEM #1 and MEM #2 registers of the 19XT and use the SCAN function to automatically cycle between these two attenuation limits. In either case, this increases or decreases the light input to the 22XLC/550 receiver, and applies a corresponding voltage to the Y axis of the plotter. The X axis voltage signal from the 22XLC determines how this 22XLC/550 combination performs. A roll off from a straight line plot at some dB value of attenuation measures the low level detection limit of the 22XLC/550 optical power meter.

5.3 EXTERNAL CONTROL IN (Analog Input Control)

When the **EXTERNAL CONTROL** switch (at the left side of the instrument) is in the ON position, the front panel functions - **[UP]**, **[DOWN]**, **[SCAN]**, and Repeat Scan - are disabled. The attenuation is controlled by an analog input voltage. The control factor is 25dB of attenuation per +1 Volt of input. Analog input should be hooked up to the BNC connector next to the label **EXTERNAL CONTROL IN.**

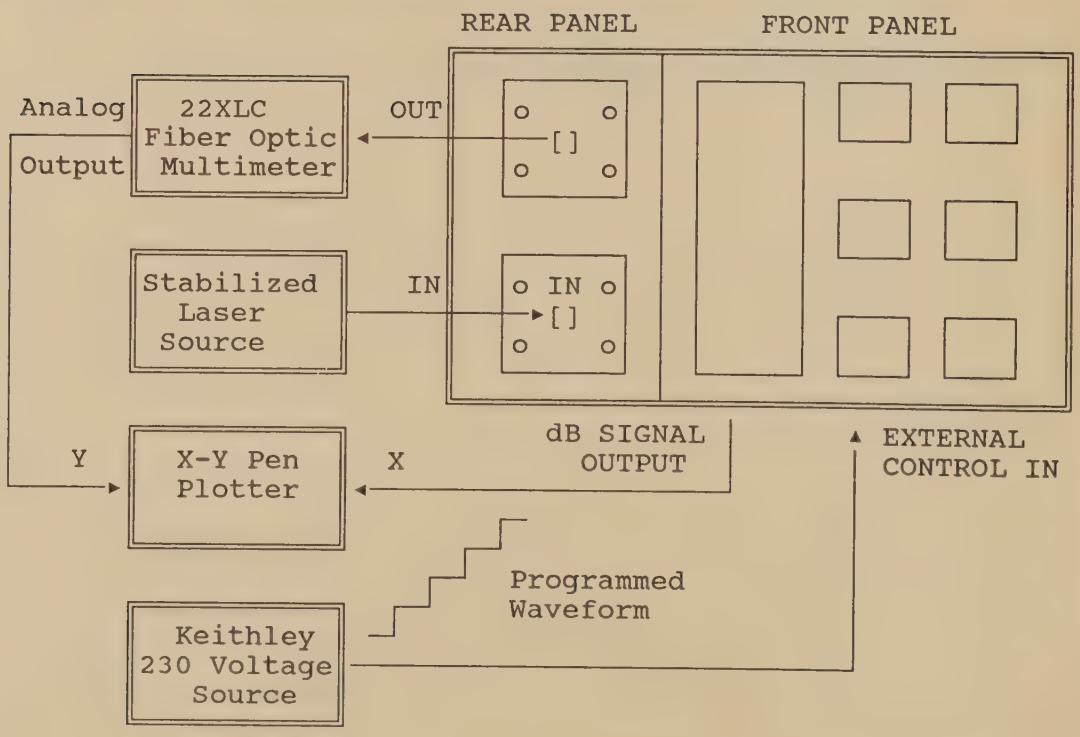


FIGURE 5.2 BLOCK DIAGRAM OF AUTOMATIC TEST SETUP USING 19XT EXTERNAL CONTROL IN

The block diagram of Figure 5.2 illustrates how a programmable voltage source (such as the Keithley 230) can control the 19XT via the **EXTERNAL CONTROL IN.** In this setup, the user can store an output waveform program in the Keithley 230 which will directly control the 19XT. This method allows the user to program any type of control waveform - ramp, staircase, etc. - versus the ramp-only capability of the 19XT SCAN function. The GPIB control capability of the Keithley 230 (with the analog input control of the 19XT) is the heart of the 19XT Automatic Calibration System (see Section 7.4).

6. PERFORMANCE VERIFICATION

6.1 Introduction

This section contains information necessary to verify that the Model 19XT performance is operating within published specifications (see Section 1.2). Ideally, performance verification should be performed when the instrument is first received to ensure that no damage or change in calibration has occurred during shipment. The verification procedure may also be performed whenever instrument accuracy is suspect, or following calibration. Furthermore, PHOTODYNE recommends that a performance verification be done at least once a year.

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* NOTE *
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IF THE INSTRUMENT DOES NOT MEET SPECIFICATIONS AND IS STILL UNDER WARRANTY (LESS THAN 12 MONTHS SINCE DATE OF SHIPMENT), CONTACT YOUR LOCAL PHOTODYNE REPRESENTATIVE OR THE FACTORY TO DETERMINE THE ACTION TO BE TAKEN.

6.2 Environmental Condition

All measurements should be made at an ambient temperature between 18°C and 25°C (64°F to 77°F) with a relative humidity less than 60%.

6.3 Recommended Test Equipment

Equipment for verifying the performance of the Model 19XT is listed in Table 6.1. Alternate equipment may be used as long as the equipment accuracy is at least as good as the specifications listed in Table 6.1.

Basically, the test set-up requires a stable source, a highly linear photodiode, and a picoammeter. The photodiode (or high performance optical power meter such as the Photodyne Model 2275XQ) should be selected for the highest responsivity and lowest noise at the desired calibration wavelength. The source may be either an LED or laser as long as a fiber optic pigtail with a reliable termination is available. Selection of the source will depend upon the spectral bandwidth requirements of the user. For example, an LED source has a wider spectral half-bandwidth (typically 50nm) than a corresponding laser (typically 2nm) with the same center wavelength. Thus, calibrations with an LED source should be applied only to LED-based systems; laser source calibrations applied only to laser-based systems. **PHOTODYNE CALIBRATES THE MODEL 19XT WITH LASER SOURCES.**

The recommended test equipment listed in Table 6.1 is an example for a 1300nm single mode laser application. Only the source and patch cords need to be changed for other wavelengths and fiber sizes.

TABLE 6.1

RECOMMENDED TEST EQUIPMENT

EQUIPMENT	SPECIFICATIONS
Photodyne Model 2275XQ Programmable Fiber Optic Power Meter	Cal Wavelength: 1300nm Dynamic Range: +6 to -70dBm Noise Floor: -80dBm (nominal)
Photodyne Model 7160XF-010W Laser Source	Single-mode laser source with AT&T 1016A Biconic Termination Peak wavelength: 1300 nm
Photodyne Model 1230-010W (3 required)	Fiber: 3meter, SM 9/125µm AT&T 1016A Biconic Terminations
Photodyne Model 2017 Biconic Adaptor	Fiber Optic Adaptor for 2275XQ
AT&T Model 1013A Coupler (2 required)	AT&T Single Mode Biconic Coupler
Keithley Model 485 Autoranging Picoammeter	2mA,200uA,20ua ranges: ± 0.1% 2uA range: ± 0.15% 200nA range: ± 0.2%
Thermoelectrically-cooled Germanium Photodiode and Cooler Controller (May Substitute InGaAs PD)	Responsivity: 0.5 A/W, minimum Response Uniformity: ± 2% Linearity: ± 2% Shunt Resistance @ 0V @ -30°C: 250kΩ,minimum

6.4 Initial Conditions

Before performing the verification procedures, make sure the Model 19XT meets the following conditions:

1) If the instrument has been subject to temperatures below 18°C (64°F) or above 25°C (77°F), allow sufficient time for the instrument to reach temperatures within the range. Generally, it takes one hour to stabilize an instrument that is 10°C (18°F) outside of this range.

2) Connect the Model 19XT to a Photodyne "B" series (100B,

115B, or 220B) power supply/charger.

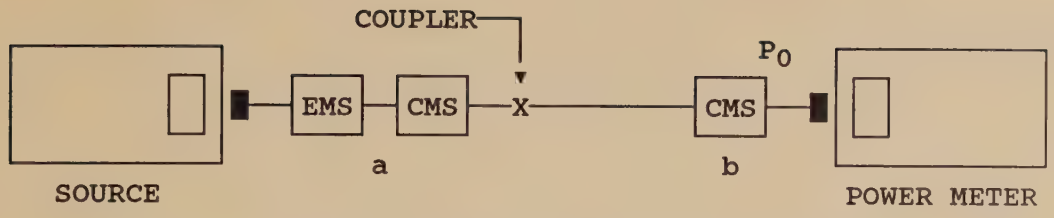
3) Turn on the Model 19XT and allow it to warm up for 15 minutes.

6.5 Auto Test

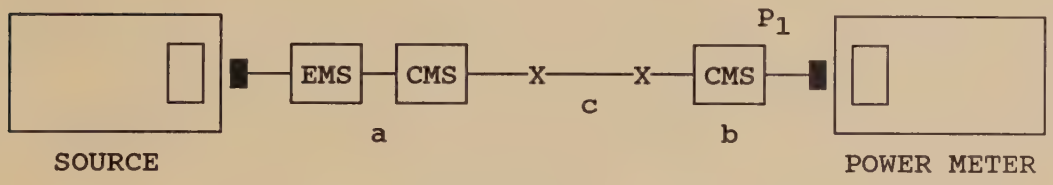
Press and hold the [X+B] button for five seconds, until the X+B indicator blinks. Then press and hold the [λ] button for five seconds, until the display blanks. The 19XT Will then display the software version number. It then tests the RAM memory and the EEPROM memory. An appropriate error code will be displayed if there is an error (see Section 3.11). Press any key to resume the AUTO TEST after an error. The 19XT will then turn on the whole display. It will then individually turn on and off each LCD digit and annunciator.

6.6 Verify Test Cables

Before verifying the optical characteristics of the 19XT, it is necessary to verify the quality of the test cables to be used. The following test procedure is based on EIA FOTP-171, "Attenuation By Substitution Measurement - For Short Length Multimode Graded Index and Single Mode Optical Fiber Assemblies." The test procedure is illustrated in Figure 6.1.



(A) P_A = Initial reference power level



(B) P_B = Test cable power level

a = Reference Launch Cable
b = Reference Receive Cable
c = Cable Assembly under Test
EMS = Equilibrium Mode Simulator
CMS = Cladding Mode Stripper

Figure 6.1 Block Diagram for Verifying Test Cables.

1) Assemble the equipment per Figure 6.1(A). Connect the source to your launch cable with an EMS and CMS formed on this cable. Connect the other end of your launch cable to your receive cable via a bulkhead coupler. The other end of your receive cable connects to the sensor input of the optical power meter via the proper 2000 Series Fiber Optic Adaptor (Model 2017 for Biconic connectors).

NOTE

An EMS is an apparatus, such as a Mandrel Wrap, or suitable optics capable of simulating within a short fiber, the equilibrium mode distribution exiting a long fiber under steady state conditions. Example: Five wraps of 50/125 graded index fiber on a 20 mm (0.788-inch) diameter rod simulates the far field output radiation pattern of a fiber one kilometer in length. Consult EIA FOTP-50 for further information.

NOTE

A cladding mode stripper (CMS) requires a refractive index greater than that of the cladding. CMS are used to simulate the attentuation of cladding energy as normally occurs in the first few meters of fiber length. Today's fibers are cladding mode stripped, so this is usually not necessary.

2) Measure and record the optical power in dBm exhibited at the end of cable "b". Do this a total of ten times, each time recoupling and/or rotating the connections on both sides of the coupler. Calculate both the average, P_A, and standard deviation, σ_A, of these readings:

$$P_A = \frac{P_1 + P_2 + \ldots + P_{10}}{10}; \qquad \sigma_A = \sqrt{\frac{1}{9}\sum_{i=1}^{10}(P_i - P_A)^2}$$

3) The cable assembly to be tested is inserted between the reference launch cable (a) and reference receive cable (b) completing the optical path, as shown in Figure 6.1(B).

4) Measure and record the power (P_1) in dBm exhibited on the power meter in the test data.

5) Repeat step 4 at least four more times, each time recoupling and/or rotating the connections. Now reverse the test cable. Measure and record 5 additional readings as previously described. This will ensure that any reversability is accounted for in the measurement.

6) Calculate both the mean value, P_B, and standard deviation, σ_B, of the 10 power readings (obtained from steps 4 and 5) for this cable assembly:

$$P_B = \frac{P_1 + P_2 + \ldots + P_{10}}{10}; \qquad \sigma_B = \sqrt{\frac{1}{9}\sum_{i=1}^{10}(P_i - P_B)^2}$$

The dB loss of this cable assembly is:

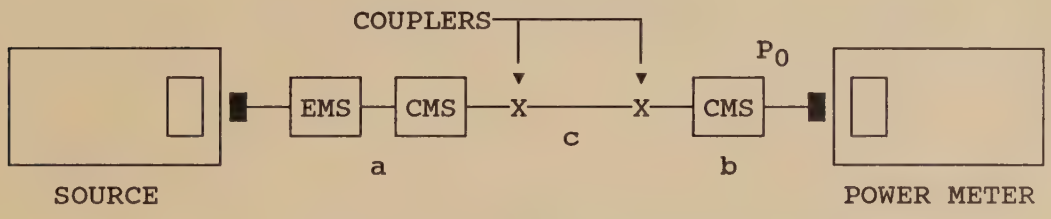
$$\text{Loss} = P_A - P_B$$

For a good quality test cable, the σ_A and σ_B should not exceed 0.2dB (except AMP SIMPLEX and SMA connectors which will be much higher).

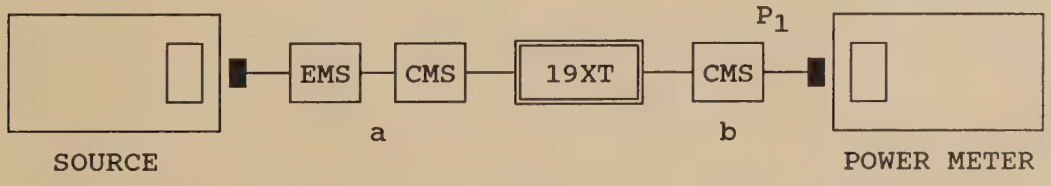
6.7 Verify Internal Insertion Loss

Proceed as follows to check the internal insertion loss of the 19XT:

1) Assemble the equipment as shown in Figure 6.2(A).



(A) P_C = Initial reference power level



(B) P_D = Power reading with 19XT in-circuit

a = Reference Launch Cable
b = Reference Receive Cable
c = Reference Inline Cable
EMS = Equilibrium Mode Simulator
CMS = Cladding Mode Stripper

Figure 6.2 Block Diagram for Verifying Internal Insertion Loss.

2) Use the Model 19XT [λ] key to select the proper cal wavelength.

3) Using the Model 19XT **[UP]** or **[DOWN]** function keys, set the display to 0.0dB.

4) On the Photodyne 2275XQ, press **[DC]** to select DC power reading. Press **[dBm]** to select log units. Be sure that the 2275XQ is properly ZEROed with a blank cap installed over the detector. Consult Section 3.5 of the Photodyne 2275XQ instruction manual for proper procedures. Failure to properly follow this step degrades the accuracy of this procedure.

5) Measure and record the optical power in dBm exhibited at the end of cable "b". Do this a total of ten times, each time recoupling and/or rotating the connections on both sides of both couplers. Calculate both the average, P_C, and standard deviation, σ_C, of these readings:

$$P_C = \frac{P_1 + P_2 + \ldots + P_{10}}{10}; \qquad \sigma_C = \sqrt{\frac{1}{9}\sum_{i=1}^{10}(P_i - P_C)^2}$$

6) Consult Figure 6.2(B). Remove the Test Cable "c" and the two couplers, and insert the 19XT in place. Be sure to reference the 1300nm calibration scale on the dial readout.

7) Measure and record the optical power in dBm exhibited at the end of cable "b". Do this a total of ten times, each time recoupling and/or rotating the connections to the 19XT optical ports. Calculate both the average, P_D, and standard deviation, σ_D, of these readings:

$$P_D = \frac{P_1 + P_2 + \ldots + P_{10}}{10}; \qquad \sigma_D = \sqrt{\frac{1}{9}\sum_{i=1}^{10}(P_i - P_D)^2}$$

8) Calculate the internal insertion loss of the 19XT:

$$\text{Loss} = P_C - P_D - (\sigma_A + \sigma_B + \sigma_C + \sigma_D)$$

This value should be ≤3.5dB for multimode models, and ≤5dB for single mode versions. Please note that the σ factors account for the performance variation, or

uncertainty, associated with a particular connector type. Photodyne guarrantees that all terminations meet or exceed the manufacturer's specifications. However, Photodyne makes no guarrantees as to the validity of performance claims that a particular manufacturer may make of his connector.

The purpose of the "rigourous" measurements described in this section is to make the user aware of the "real world" performance of a particular connector type. Most manufacturers quote an average insertion loss and a standard deviation of random intermatings. As a practical matter, these statistical results indicate to a user that he can expect insertion losses within $\pm 2\sigma$ of the mean value for 90% of all random matings. Thus, 10% of all matings will fall outside this range. The smaller the σ, the higher the "precision" or repeatability of a particular connector design.

6.8 Verify Accuracy

PHOTODYNE originally calibrates all Model 19XTs with laser sources. Calibration and use with LED sources may produce calibration differences of as much as ± 0.5dB. This can occur because of wavelength differences and modal differences. It is recommended for highest accuracy work that a calibration sheet, as described in this section, be filled out for your particular source. When working with single mode lasers and single mode fibers, the input and output fibers to the Model 19XT must be kept straight and stable during the measurement process. Fiber motions can produce laser longitudinal mode shifts in some single mode laser/fiber source combinations.

Proceed as follows to check the accuracy of the Model 19XT:

1) Assemble the test equipment as shown in Figure 6.3.

This is the same as the last setup used in the previous section.

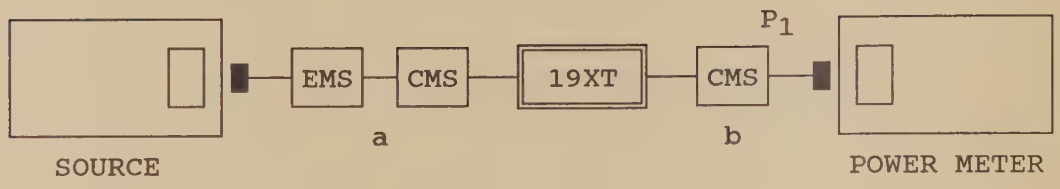


FIGURE 6.3 BLOCK DIAGRAM FOR VERIFYING CALIBRATION ACCURACY

2) Use the Model 19XT [λ] key to select the proper cal wavelength.

3) Using the Model 19XT **[UP]** or **[DOWN]** function keys, set the display to 0.0dB.

4) On the Photodyne 2275XQ, depress [DC] to select DC power reading. Be sure that the 2275XQ is properly ZEROed with a blank cap installed over the detector. Consult Section 3.5 of the Photodyne 2275XQ instruction manual for proper procedures. Failure to properly follow this step degrades the accuracy of this procedure.

5) Optimize all fiber optic connections by re-coupling and/or rotating all connectors for the highest power reading obtained via the 2275XQ. The highest signal-to-noise ratio is required to verify proper performance. At least 0.00dBm (after connector losses) optical power is required at the input of the Model 2275XQ to verify the full range of the Model 19XT. Less signal power will require reducing the bottom range of this verification procedure. In addition, reduce the attenuation testing according to the range limits (versus cal wavelength) given in the specifications.

6) On the Photodyne 2275XQ, momentarily depress [dB]. The meter should now read 0.00 dB.

7) Use the Model 19XT **[UP]** and **[DOWN]** function keys to sequence through dB setting as given in Table 6.2. Record readings directly from Photodyne 2275XQ.

TABLE 6.2

CALIBRATION ACCURACY CHART

19XT dB Setting	Measured Value in dB	Allowable Readings
- 0.0	_____	- 0.00 to - 0.50 dB
- 1.0	_____	- 0.50 to - 1.50 dB
- 2.0	_____	- 1.50 to - 2.50 dB
- 3.0	_____	- 2.50 to - 3.50 dB
- 4.0	_____	- 3.50 to - 4.50 dB
- 5.0	_____	- 4.50 to - 5.50 dB
- 6.0	_____	- 5.50 to - 6.50 dB
- 7.0	_____	- 6.50 to - 7.50 dB
- 8.0	_____	- 7.50 to - 8.50 dB
- 9.0	_____	- 8.50 to - 9.50 dB
- 10.0	_____	- 9.50 to -10.50 dB
- 11.0	_____	-10.50 to -11.50 dB
- 12.0	_____	-11.50 to -12.50 dB
- 13.0	_____	-12.50 to -13.50 dB
- 14.0	_____	-13.50 to -14.50 dB
- 15.0	_____	-14.50 to -15.50 dB
- 16.0	_____	-15.50 to -16.50 dB
- 17.0	_____	-16.50 to -17.50 dB
- 18.0	_____	-17.50 to -18.50 dB
- 19.0	_____	-18.50 to -19.50 dB
- 20.0	_____	-19.50 to -20.50 dB
- 21.0	_____	-20.50 to -21.50 dB
- 22.0	_____	-21.50 to -22.50 dB
- 23.0	_____	-22.50 to -23.50 dB
- 24.0	_____	-23.50 to -24.50 dB
- 25.0	_____	-24.50 to -25.50 dB
- 26.0	_____	-25.48 to -26.52 dB
- 27.0	_____	-26.46 to -27.54 dB
- 28.0	_____	-27.44 to -28.56 dB
- 29.0	_____	-28.42 to -29.58 dB
- 30.0	_____	-29.40 to -30.60 dB
- 31.0	_____	-30.38 to -31.62 dB
- 32.0	_____	-31.36 to -32.64 dB
- 33.0	_____	-32.34 to -33.66 dB
- 34.0	_____	-33.32 to -34.68 dB
- 35.0	_____	-34.30 to -35.70 dB
- 36.0	_____	-35.28 to -36.72 dB
- 37.0	_____	-36.26 to -37.74 dB
- 38.0	_____	-37.24 to -38.76 dB
- 39.0	_____	-38.22 to -39.78 dB

7. MAINTENANCE

7.1 General

This section contains information necessary to maintain the Model 19XT Optical Attenuator. Calibration, adjustment, trouble-shooting, and all other information pertinent to maintenance is provided.

****
* NOTICE *
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Sections 7.2 through 7.3 describe internal electronic adjustments that are accessible to the user. However, the absolute dB calibration (as decribed in Section 7.4) requires an automated test setup which commits the final calibration data to a special PROM device. This custom calibration can only be performed at a Photodyne service facility.

7.2 Initial Conditions

Before performing the calibration procedures, make sure the Model 19XT meets the following conditions:

1) If the instrument has been subject to temperatures below 18°C (64°F) or above 25°C (77°F), allow sufficient time for the instrument to reach temperatures within the range. Generally, it takes one hour to stabilize an instrument that is 10°C (18°F) outside of this range.

2) Connect the Model 19XT to a Photodyne "B" series (100B, 115B, or 220B) power supply/charger.

3) Turn on the Model 19XT and allow it to warm up for 15 minutes.

7.3 Electronic Adjustments

The following procedures describe internal adjustments that can be performed by the user.

7.3.1 Recommended Test Equipment

Consult Table 7.1 for the recommended test equipment needed for this section.

TABLE 7.1

RECOMMENDED TEST EQUIPMENT

EQUIPMENT	SPECIFICATIONS
Keithley Model 175 4.5-Digit Multimeter (DMM)	2 DCV Range: ±(0.03% + 1) 20 DCV Range: ±(0.03% + 1)
Keithley Model 230 Programmable Voltage Source	1 V Range: ±(0.005% + 25μV) 10 V Range: ±(0.005% + 100μV)
Hewlett-Packard 6216B DC Power Supply	Range: 0-30 volts, 500mA max.

7.3.2 LCD Contrast Adjustment

1) Set **EXT CONTROL** switch to off.

2) Adjust trimpot R38 until all segments of the LCD readout are visually sharp and without shadows.

7.3.3 Voltage Regulation Adjustment

1) Connect DMM between GND and pin 8 of U15.

2) Adjust R37 for reading of 10.00 volts.

3) Connect DMM between GND and pin 4 of U15. Meter should read -9.50 volts, nominal.

7.3.4 Positioning Window Adjustment

1) Connect DMM between GND and the end of R9 closest to C11.

2) Adjust R10 until DMM reads 2.440 volts.

3) Connect DMM between GND and end of R11 closest to R9.

4) Adjust R12 until DMM reads -2.440 volts.

7.3.5 Analog Output Adjustment

1) Press [UP] key until 19XT reads **20.0dB**.

2) Connect DMM (via BNC adaptor cable) to external BNC connector labelled **dB SIGNAL OUT**.

3) Adjust R15 until DMM reads 2.000 volts.

4) Press [UP] key until 19XT reads **30.0dB**. DMM should read 3.000 $\pm$0.003 volts.

5) Press [UP] key until 19XT reads **100.0dB MAX**. Observe that mechanical assembly moves freely without binding or dragging.

6) Hold down [UP] key until 19XT reads **HI**. Observe freedom of movement of mechanical assembly.

7) Depress [**DOWN**] until 19XT reads **0.0dB MIN**. Observe operation of mechanical assembly while 19XT repositions to 0.0dB.

7.3.6 Analog Input Adjustment

1) Connect Keithley 230 voltage source to external BNC connector labelled **"EXTERNAL CONTROL IN."** Set **EXTERNAL CONTROL** switch to **ON**. 19XT readout should display **"EXT CTRL."**

2) Set voltage source to 0.000 volts. 19XT should stabilize at the home position and read **"0.0dB MIN"** ($\pm$0.1dB).

3) Set voltage source to 1.000 volt. 19XT should stabilize and read "25.0dB" (±0.2dB). If necessary, adjust R5 so that 19XT displays "25.0dB."

4) Set voltage source to 0.000 volts. 19XT should stabilize at the home position and read "0.0dB MIN" again.

5) Adjust R7 clockwise until LCD reads "0.1dB." Adjust R7 counter-clockwise until 19XT just begins to display "0.0dB MIN." Finally, turn R7 an additional quarter turn counter-clockwise. ANALOG INPUT OFFSET adjustment is now completed.

6) Set voltage source to 1.000 volts. 19XT should stabilize and read "25.0dB" (±0.2dB). If necessary, adjust R5 until 19XT reads "25.0dB."

7) Set voltage source to 2.000 volts. 19XT should stabilize and read "50.0dB" (±0.2dB).

8) Set voltage source to 3.000 volts. 19XT should stabilize and read "75.0dB" (±0.2dB).

9) Set voltage source to 0.000 volts. Observe that mechanical assembly operates freely as filter returns to home position. Final readout should be "0.0dB MIN."

10) Set EXTERNAL CONTROL switch to OFF position.

7.3.7 LOW Battery Indicator

1) Turn 19XT off. Disconnect Photodyne "B" series Power Supply/Charger from 19XT.

2) Connect DC power supply to input. Inside pin of receptacle (or socket contact of plug) is negative. Connect voltmeter across power supply.

3) Turn power supply on and set to 8.0 volts. Turn 19XT on.

4) Decrease voltage slowly. The 19XT display should indicate "LO BAT" as the voltage dips below 7 volts, nominal.

5) Increase voltage slowly. The "LO BAT" indicator should disappear as the voltage climbs above 7 volts, nominal. There are no adjustments for the LO BAT

function, simply verify correct operation of the annunciator.

6) Disconnect power supply. Reconnect Photodyne "B" series Power Supply/Charger to 19XT.

7.4 Optical Attenuation Calibration

Every Model 19XT is individually calibrated at Photodyne, with a computer-controlled automatic measurement and PROM programming system. The calibration setup is similar to that used for Section 6, Performance Verification, except it is completely GPIB- controlled. The 19XT is under total GPIB control via the **"EXTERNAL CONTROL"** analog input and the **"dB SIGNAL OUT"** analog output.

The custom programmed microcomputer chip for each 19XT is the end result of this process. The resulting "Calibration Accuracy Chart" is internally stored in this device. This memory chip is not re-programmable,thus, re-calibration can only be done by Photodyne service centers.

It is recommended that the 19XT be recertified at least every 12 months. If the unit does not pass the performance verification tests, then the calibration accuracy chart should be used with the unit, or the unit should be sent to Photodyne for re-calibration. This service is available for a nominal fee.

The remainder of this section will descibe the calibration system for the reference of the end user.

7.4.1 Calibration Principles

The basic references for the 19XT calibration process are silicon photodiodes for the shortwave region at 820-850nm and thermoelectically-cooled germanium photodiodes (or InGaAs photodiodes) for the longwave regions at 1300nm and 1550nm. These detectors are selected devices whose linearity has been established as better than 2% over a 70 dB range. This is verified with absolute attenuation techniques. These photodiodes are used in the calibration setup of the following section, in order to generate the custom dial. Alternately, the photodiode/picoammeter combination may be substituted with a high-performance GPIB optical power meter, such as the Photodyne Model 275XQ.

7.4.2 Calibration Setup

Every 19XT is individually calibrated for attenuation at two wavelengths using laser sources. Multimode versions are calibrated at 850nm and 1300nm. The single mode versions are calibrated at 1300nm and 1550nm. The custom calibration data is programmed into a microcomputer memory chip. With the automated test setup shown in Figure 7.1,

the measurement uncertainties are estimated to be less than 0.2dB.

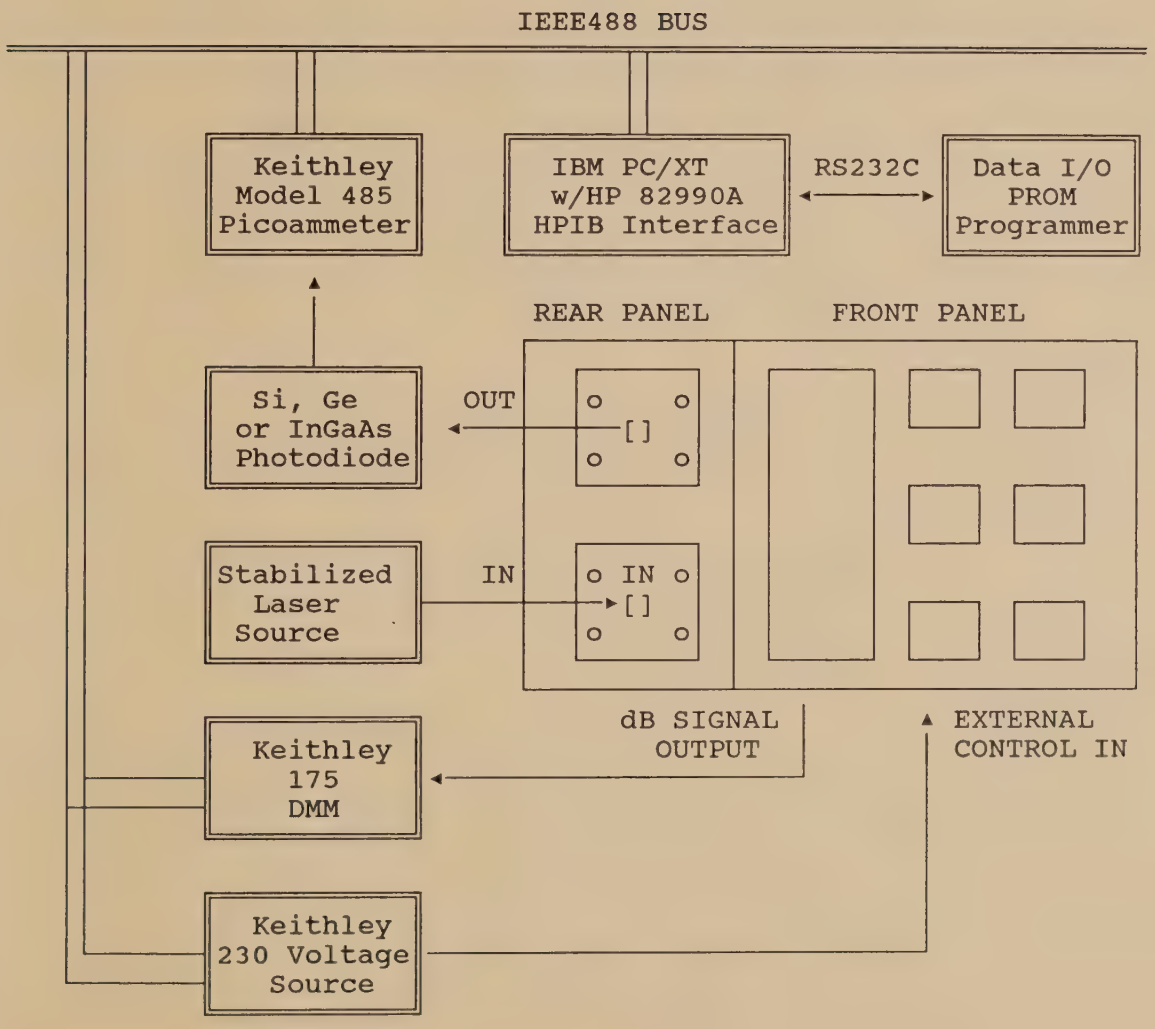

FIGURE 7.1 BLOCK DIAGRAM OF CALIBRATION SETUP

7.5 Trouble-Shooting

The trouble-shooting instructions contained in this section are intended for qualified personnel having a basic understanding of electronics and optics. The individual should also be experienced at using test equipment as well as ordinary trouble-shooting procedures. The information presented here has been written to assist in isolating a defective circuit or circuit section; isolation of the specific component is left to the technician.

****
* NOTE *
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AVOID TOUCHING A PC BOARD OR ITS COMPONENT PARTS. ALWAYS HANDLE A PC BOARD BY ITS EDGES.

Tables 7.2 and 7.3 describe in detail the causes and remedies for many common problems. All other problems should be referred directly to the factory.

TABLE 7.2

ELECTRICAL TROUBLE-SHOOTING GUIDE

PROBLEM	CAUSE	CHECK
No display when turned on	Battery or Charger/ Power Supply	Check charger output 12 volts, nominal. Display should come on with charger plugged in, even if battery is dead.
Missing segment on LCD display	Loose LCD mount	Check that LCD is securely seated in socket on circuit board with no bent pins.
Front panel keys are intermittent or non-operative	Loose keyboard connection	Check that front panel cable is securely connected to circuit boards. Connector J2.
Analog output voltage does not correspond to 1 volt per 10dB	Potentiometer setting is incorrect	Adjust R39 on circuit board until 10dB/volt is attained.
Analog input voltage does not control attenuation	External Control Switch position	Move External Control Switch to the ON position.
Neither analog input nor analog output are functioning	Loose cable assembly	Check cable assembly to circuit board from side switch and BNC connector.

TABLE 7.3

OPTICAL TROUBLE-SHOOTING GUIDE

PROBLEM	CAUSE	CHECK
High insertion loss	Dirty or loose connector	Clean all connectors with soft lint free cloth and alcohol.
Display does not match measured values of attenuation	Wavelength of operation different from selected wavelength.	Check that selected 19XT wavelength matches operating (system) wavelength via [λ] function key.
Measured attenuation drops to low value while display continues to show increased attenuation	Cracked or broken attenuating element	Send back to factory for repair

8. REPLACEABLE PARTS

8.1 General

This section contains information necessary for ordering replacement parts.

8.2 Ordering Information

To place an order or to obtain information concerning replacement parts, contact your local PHOTODYNE Representative or PHOTODYNE Headquarters. When ordering, include the following information:

1) Instrument Model Number
2) Instrument Serial Number
3) Part Description
4) PHOTODYNE Stock Number

8.3 Schematics

Figure 8.1 Schematic Diagram

Figure 8.2 Component Layout

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED
D	Revised per Remarq RCN 1059	5/3/93	
E	ECN 1077 (Software)	6/14/93	
F	ECN 1117		
F1	ECN 1191 (Hardware)	10/4/93	

PHONE JACK
J1
8.4V 225 MAH
ANALOG IN BNC
R1 150Ω
CR1 IN914
R2 10K
R3 10K
CR5
C1 .1MF
LT1013 U5
+10V
-10V
C2 .1MF
C3 .1MF
R4 10K
U7 - AD537J
C4 100pF
R5 250K
R6 8K
R7 20K
+10V
R8 10K
+5V
R48 475K
C5 10MF
C6 .1MF
VR3 LM293/A2-5
C7 100MF
C8 100MF
CR2 IN4148
CR3 IN4148
R9 100K
R10 200K
R11 100K
R12 200K
U4 LT1013
C9 .1MF
C10 .1MF
-10V
R13 10K
R14 10K
C11 .1MF
C12 .1MF
U6 VQ3001J
J1
C13 1MF
R15 1M
J1
ANALOG OUT BNC
U3 LT1013
R16 100K
U1 LT1013
C22 .1MF
C19 .1MF
R23 47Ω
C21 33pF
R17 10M
U2 LT1013
R21 9.76K
R22 47Ω
C20 33pF
R20 9.76K
TP2
TP3
TP1 -3.0V
C18 .1MF
R18 100K
C16 .1MF
C17 .1MF
R19 100K
TP4 +5.0V
J1
10K
U8 AD7549
IOUTB
VDD
GND
RFBB
IOUTA
CLR
AGND
RFBA
UPD
DB0
DB1
DB2
DB3
A0
A1
A2
WR
U14 AD584
VOUT
GND
VOS
VIN
R24 100K
U11 74C74
R25 100K
R26 100K
C27 .1MF
R27 100K
C26 .1MF
U10 74C221
R28 500MΩ
C28 100pF
Q1 VP1204N2
R29 750Ω
R30 50K
Q2 2N2222A
R31 499K
R46 100K
Q4 IVN5200 TNB
R42 100K
R43 100K
R44 100K
R45 100K
U9 CAT93CA6
C25 .1MF
Y1 4MHz
C29 20pF
C30 20pF
R40 100K
J1
INT=1 EXT=0
C31 1MF
U12 HG63701 Vo
P21
VPP/RES
NMI
P20
P22
P24
XTAL
VSS
EXTAL
P10
P11
P12
P13
P14
P15
P16
P23
P17
IRQ1
STBY
P30
P31
P32
P34
P35
P36
P37
P40
P41
P42
P43
P44
P45
P46
P47
E
SC1
SC2
N.C.
N.C.
LM293/A8-5
VR1
C33 100MF
C34 100MF
+5V
LM293/T
VR2
C32 100MF
R36 28K
C35 100MF
R37 200K
R32 182K
R33 255K
R34 255K
R35 100K
U5 LT1013
R47 20K
U15 MAX680
C36 22MF
C37 22MF
C38 .1MF
C39 22MF
C40 .1MF
C41 22MF
+10V
-10V
GND
R41 100K
Q3 2N2222A
R38 200K
R39 10K
U13 ICM7231CF
VDISP
CS
A0
A1
A2
BD0
BD1
BD2
BD3
AN1
AN2
C42 .1MF
RN1 100K
CR4 IN914
J2
ON/OFF
SCAN
UP
X+B
DOWN
LCD
COM1
COM2
COM3
1Z
1Y
1X
2Z
2Y
2X
3Z
3Y
3X
4Z
4Y
4X
5Z
5Y
5X
6Z
6Y
6X
7Z
7Y
7X
8Z
8Y
8X

PHOTODYNE INC.
1175 Industrial Drive Hemet, California 92343

SCHEMATIC
19XT

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RMB
C
CRS

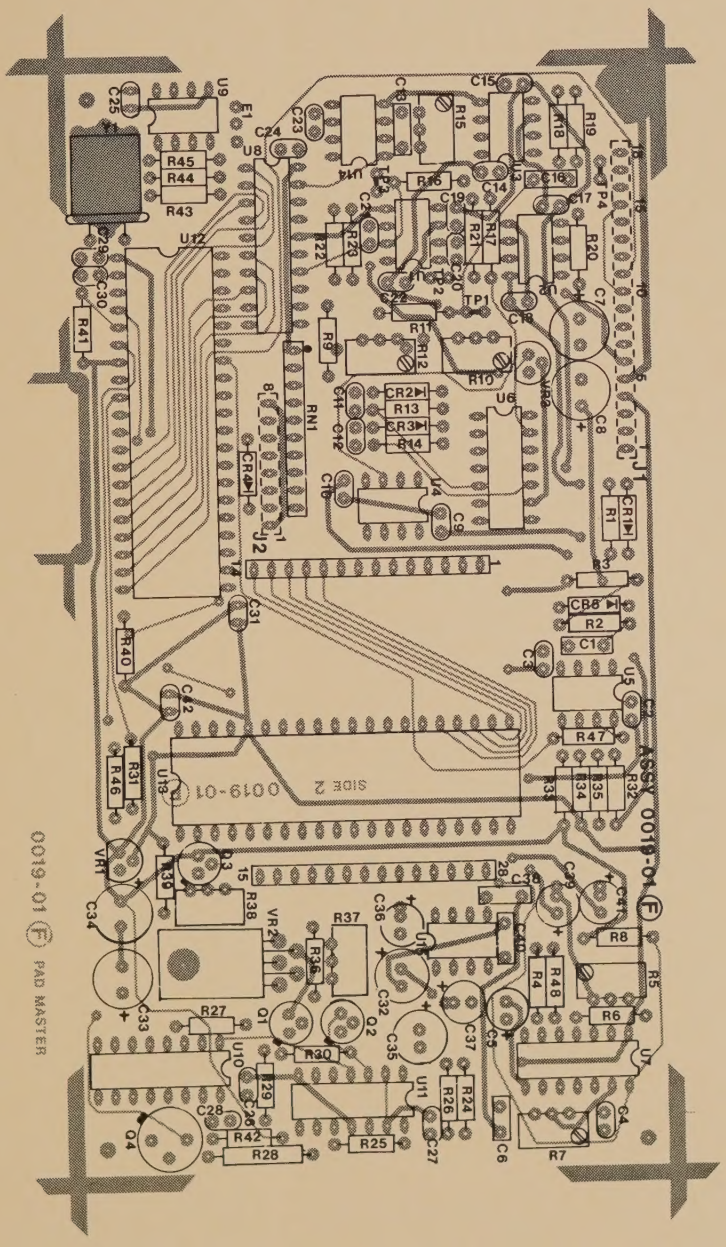

Figure 8.2 Component Layout

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LOC: T1
MAN - 03044

3M Photodyne Inc.
3760 Calle Tecate
Camarillo, CA 93010
805/388 8378
Telex: 910 250 8611
FAX: 1 805/499 9311

3M Photodyne-Europe Inc.
Hollandschdiep 69
2904 Ep Capelle A/D, Holland
31/10/458 3055
TELEX: 23746
FAX: 011-31-10-458-1905

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